N89-15032

# LOW-GRAVITY FACILITIES FOR SPACE STATION PLANETOLOGY EXPERIMENTS

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For experimentation, space offers a unique environment which is unobtainable on Earth. One characteristic is a gravity force less than 1 g, where g is the mean Earth gravity acceleration of 9.8 $m/s^2$.

A near-zero g level is easiest to obtain, since orbiting spacecraft are in free fall. This condition, which is desired for many science and engineering applications, is referred to as microgravity. Total elimination of acceleration is difficult since perturbing forces, such as atmospheric drag, expulsion of mass, and disturbances, will contaminate the gravity environment. The purity of zero g is specified by some level of noise, such as $10^{-4}$ g; however, no single number can really indicate the true nature of the noise, which may be high frequency, low frequency, or intermittent.

Producing uniform gravity level about zero g in space is quite different than producing microgravity. Here, a constant force must be produced over long periods of time. Thrust may be applied to spacecraft to produce low gravity, but this is not very practical, except perhaps with solar sails. For Earth orbital facilities, two methods are possible: (1) centrifugal force through rotation, or (2) gravity gradient force using long tethers. Which approach should be used depends on many factors, both from the standpoint of user requirements, and from design, implementation, operation and cost considerations. This presentation identifies the major parameters which should be considered in any design. It also presents some basic characteristics of rotating and gravity gradient tethers, and evaluates possible conceptual designs.

For planetology experiments, providing gravity in space will make it possible to more nearly simulate conditions on natural bodies. Its presence may be unnecessary for simulation of comet surfaces, since gravity is of the order of $1 \times 10^{-5}$ g; however, for other bodies, it may be important. In terms of Earth gravity, the g-levels are:

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| larger asteroids: | 0.01 - 5% |
| Moon, Io, Titan: | 15 - 20% |
| Mars, Mercury: | 35 - 40% |
| Venus, Saturn, Uranus: | 80 - 100% |

The types of planetology experiments which may be conducted under these g-levels may be impact, flow transport, and chemical reactions with solids, liquids, or gases. Also, using scaling laws, it may not be necessary to use one-to-one correspondence of the g-level with the planetary body of interest. Very likely, with each experiment, some minimal g-level will be necessary.

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* Section Staff, Mission Design. Written while on a one year assignment at NASA, Office of Space Flight, Advanced Programs, Washington, D.C. The research described in this paper was performed by the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

The g-level is but one parameter involved in the design of a specific experiment. Other requirements may be:

1. g-level range
2. g-level tolerance value
3. Coriolis tolerance value
4. Volume requirement
5. g-level duration
6. Power and materials for experiment
7. Automated operation or man-tended

These requirements, and certainly others, will dictate the type of facility which should be considered. At one extreme, the requirements should be modest, and a centrifuge within a manned module may suffice. For example, a one meter radius centrifuge with a rotation period of six seconds will produce about a 10% g-level. The Coriolis effect will be naturally high, and the usable volume small, which may or may not be a problem.

On the other hand, the planetology experiments may be such that they could only be done in a Spacelab environment: i.e., large volume, long duration, man operated, and low Coriolis effects. This may best be done by tethering a manned module from the Space Station; or by a large rotating structure not attached to the Space Station.

The larger facility, manned or unmanned, is the type being considered in this presentation. By the time that the Space Station is in operation, many tether experiments would have been done in space using the U.S.-Italian Tethered Satellite System on the Shuttle. On the second experiment, the Italian subsatellite will be tethered 100 km below the Shuttle. It will experience a g-level of about 5%. A similar tether system could be designed for use on the Space Station.

Concerning large rotating systems, the capability which must be developed for constructing the Space Station itself can be directly applied here. Also, many of the Station subsystems can be used. One configuration might be to have two laboratory modules, one at each end of a long beam structure. A hub at the center of this structure could contain a platform with required subsystems. This could also be an arrival and departure point for crew and supplies. An elevator on the structure could provide transportation from the hub to the modules at the ends.

A structure 200 m long could be set rotating using thrusters at each module. A velocity of 7 m/s would provide a 5% g level. Increasing this to 20 m/s would produce 40%. The periods of rotation would be 1.5 min. and 30 sec., respectively.

Many other configurations are also possible, and a final selection will depend on many factors including user requirements.

REFERENCE:

Life Sciences Advisory Committee (LSAC), Report No. 4, NASA Headquarters, Code EB, July 18-19, 1985.